ISSUES IN GENETIC EVALUATION OF DAIRY CATTLE FOR HEAT TOLERANCE

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INTRODUCTION

In many parts of the world, Holsteins are exposed to heat stress at least seasonally. During heat stress the production and fertility decline while health problems increase. Heat stress can be managed by physical modification of the environment (by shade, sprinklers and fans). Cooling is very effective in dry environments but less in humid. In the latter, when humidity reaches 100% at night, the evaporative cooling loses efficiency.

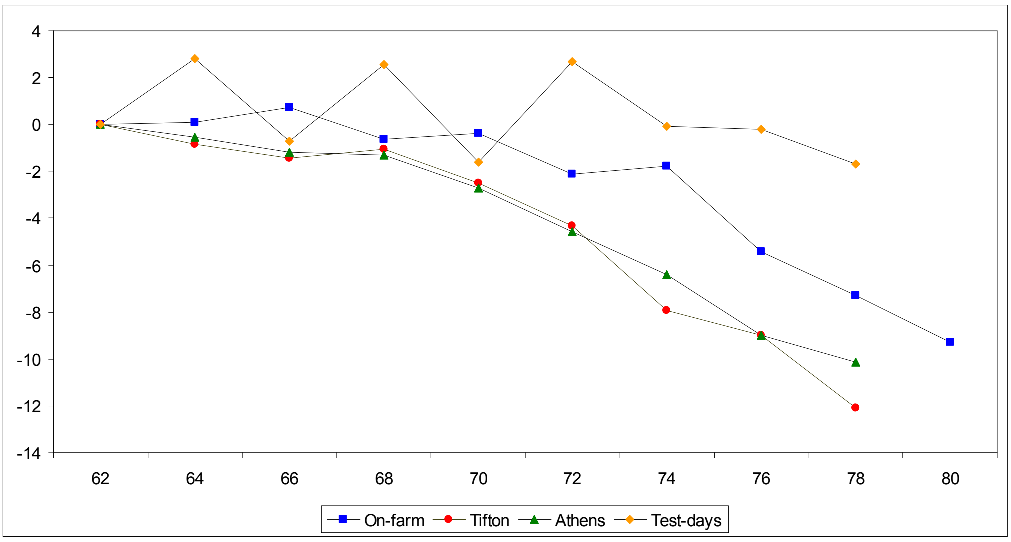
Ravagnolo et. al (2000) introduced a methodology to conduct analyzes of heat stress using publicly available information on test days from public weather stations. The methodology looks at drops of performance as a function of the temperature humidity index (THI), which is a temperature equivalent to 100% humidity. Performance of animals that drop less at high THI are considered more heat tolerant. Analyzes revealed that heat stress starts at about 19-21 degree C THI, there is substantial genetic component for heat tolerance, and the correlation between milk yield under mild temperatures and decline of yield under high THI is about -0.4 kg / degree of THI (Misztal and Ravagnolo, 2002). Subsequently, animals continually selected under cold climates would show gradually worsening performance under heat stress. Similar results have been obtained in dairy sheep (Finocchiaro et al., 2005).

The studies raised many questions. It was not clear whether the public weather stations provided accurate information, and how much more genetic variance could be captured by using on-farm measurements of THI. Second, what is the level of heat stress occurring in various geographical locations, and what is the influence of difference management systems. Finally, can the genetic evaluation for heat stress be implemented on the national scale? If yes, what would be a profile of heat tolerant bulls? Also, does heat stress explain regional differences in bull proofs in the U.S.? The purpose of this paper is to show and discuss work in genetics of heat tolerance in dairy cattle at the University of Georgia carried out since the last World Congress.

NEW STUDIES

Loss of information with weather stations. West et al (2003) looked at rates of drops of milk at high THI using on-farm measurements. Cows in the study were at the same parity and at a similar stage of lactation. Measurements were daily over a period of 3 summer months. The decline in milk was about 0.9 kg/degree of THI over the threshold. The decline in milk production was only 0.4 kg/THI in Ravagnolo et. al (2000). The last study used test days of cows in different farms at different stage of lactations and weather data from public weather stations. Freitas et al. () reanalyzed the data of West et al. (2003) adding public weather stations from 3 to over 400 km away. The response from the nearest weather station was 1.1. kg / degree THI, and was higher than with on farm measurements. Responses from more remote weather stations were all > 0.7. If the terrain is flat, the data from well managed weather stations can be as informative or more than as measured on site. The data of last study was expanded to include test days over ten years and test days from a cluster of farms. In both cases, the response was below 0.5 kg / degree. Only a fraction of response to heat stress is captured with test days as opposed to more frequent measurements especially if animals are in different stages of lactation. This is because test days provide only a few observations per year per herd, and past events that influence the test day milk including daily fluctuations of heat stress are hard to account for.

Figure 1. Decline of milk yield as a function of temperature humidity index using daily records and weather data from on-farm, Tifton (3 km away), Athens (350 km away), and using test days and a weather station from Tifton.



Heat stress and management. Data included states with seasonal heat stress such as South Dakota and parts of California. Milk yield of small herds (< 100 cows) declined with increasing THI, however, the decline was smaller or none in large herds. In areas of smaller heat stress, mainly only larger farms have cooling devices. In areas of low humidity, these devices are so efficient that the effect of heat stress on milk is hard to detect.

National genetic evaluation for heat stress. Bohmanova et al. (2005) conducted a national genetic evaluation for heat stress. The U.S. national data set consisted of 57 million first-parity test-day records of 7 million Holsteins that calved from 1993 through 2004. Hourly temperature and relative humidity records were available from 202 public weather stations across the United States. Herds were assigned by distance to the nearest weather station. The model was test-day repeatability with random regression on a function of THI. Heat-tolerance PTAs of sires ranged from ˜0.48 to 0.38 kg milk per THI unit above 72 per day; general milk-yield PTAs for sires were between ˜8.9 and 7.9 kg per day. Based on estimated heat-tolerance PTAs, the 100 most and 100 least heat-tolerant sires were selected. For each of the 200 sires, official U.S. PTAs from February 2005 were obtained. A comparison of both groups of sires is given in the Table 1. Sires that were the most heat tolerant transmitted lower milk yields with higher fat and protein contents than did sires that were the least heat tolerant. Daughters of the most heat-tolerant sires had better type, worse dairy form, better udder and body composites, higher TPI, longer productive life, and higher daughter pregnancy rate than did daughters of the least heat-tolerant sires.

Table 1. Differences of heat-tolerance PTAs and TPIs from February 2005 U.S. official evaluations for the 100 most and 100 least heat-tolerant U.S. Holstein bulls.

Trait	Most heat tolerant	Least heat tolerant	Difference between most and least heat tolerant
Milk yield (kg)[1]	−751	373	−1124.00
Fat (%)[1]	0.08	−0.02	0.10
Protein (%)[1]	0.03	−0.03	0.06
Type[2]	0.11	−0.46	0.57
Dairy form[2]	−0.49	0.96	−1.44
Udder composite[2]	0.15	−0.58	0.73
Body composite[2]	0.07	−0.25	0.32
TPI[2]	984	948	35
Productive life (mo)[1]	−0.22	−1.12	0.90
Daughter pregnancy rate (%)[1]	0.14	−1.49	1.62

[1]Official evaluation source: Animal Improvement Programs Laboratory, USDA. [2]Official evaluation source: Holstein Association USA, Inc.

Many dairy producers in the Southeastern United States are paid based on fluid milk. This pricing scheme provides incentives to select for cows with high milk yield without advantage for high fat and protein content. Based on results of this study, sires of such cows would be expected to transmit the least tolerance for heat stress. In a separate analysis, regional distribution of bulls was examined based on heat tolerance. Sires used in the Southeastern U.S. had lower heat tolerance than the average U.S. bull. Problems of heat stress in hot climates may be compounded by selection of less heat-tolerant sires.

Genotype by environment interaction due to heat stress in the U.S. The data and models from the previous study were used to calculate breeding values for the Northeast and the Southeast separately. Breeding values for mild conditions were calculated including and excluding the effect of heat stress. Correlations involved breeding values of bulls with > 300 daughters in each region. The genetic correlations when the heat stress effect was excluded were 0.86. The correlations increased by 0.01 when the effect of heat stress was considered. The increase is in the right direction but seems small. In fact, probably less than ¼ variation due to heat stress has been captured. Also, correlation lower than 1.0 is partly due to limited accuracy of sires. In reality, the heat stress may account for a large part of the genetic variation between the regions.

CONCLUSIONS

For the purpose of accounting for heat stress in dairy cattle, weather data from public weather stations may be as accurate or more as from on-farm recording. Use of test day records in such studies captures only a small fraction of variability due to heat stress because between test day variability due to heat stress is not accounted for. The response to heat stress depends on environment and management. The national evaluation for heat tolerance is possible. In the U.S., heat tolerant sires give less fluid milk, have higher milk and protein percentage, are lower on dairy form but higher on productive life and fertility. Selection on fluid milk alone reduces heat tolerance but the selection on TPI does not. Heat stress is partially responsible for G x E interaction between cold and hot regions. Continued selection for milk yield without consideration of heat tolerance results in greater susceptibility to heat stress.

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REFERENCES

Bohmanova, J., I. Misztal, S. Tsuruta, H.D. Norman and T.J. Lawlor. (2005) *Interbull Bul.* **33**:160-162.

Finocchiaro, R., J. B. C. H. M. van Kaam, B. Portolano, and I. Misztal. (2005) *J. Dairy Sci*. **88**: 1855-1864.

Freitas, M., I. Misztal, J. Bohmanova, and J. West. (2005) *J. Dairy Sci.* **88**(Suppl. 1):353.

Misztal I., and O. Ravagnolo. (2002) Proc. 7th World Congress Gen. Appl. Livest. Prod., Montpelier, France. CD-ROM communication **18**:05.

Ravagnolo, O. and I. Misztal (2000) *J. Dairy Sci.* **83**, 2126–2130.

Tsuruta, S., Misztal, I. and I. Stranden. (2001) J. Anim Sci. **79**, 1166–1172.

West, J., B.G. Mullinix, and J.K. Bernard. (2003) J. Dairy Sci. **86**:232-242.

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Several projects have been undertaken with the purpose of refining a genetic evaluation of Holstein for heat tolerance. It was found that the weather data from public weather stations may be as good or better as that collected on-farm. Also, test days capture less than one half of response to heat stress obtained with daily records. A test day model accounting for heat stress was used for the national evaluation in the U.S. Heat tolerant sires were lower on fluid milk and dairy form, neutral on TPI, and positive for fertility and productive life. G x E interaction due to heat stress can be quantified on the national scale.